PLIA “SNOW-PLOW MODE” PARAMETERS FOR AN NDCX-II FRONT END

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Background – NDCX-1c Design Studies (~ 2005)

- NDCX-1c was originally planned to be the first experimental test of an accel-decel injector, plus beam compression and extraction with a resistive column or a PLIA in snow-plow mode
- Parameters: 100 mA, 1 usec K+ beam, decelerated to ~ 55 keV (initial line charge ~ 0.2 ucoul/meter)
- WARP studies explored PLIA "knobs" to optimize bunching and control head/tail (D Grote) - see E Henestroza et al PAC 05 paper

  "EXTRACTION COMPRESSION AND ACCELERATION OF HIGH LINE CHARGE DENSITY ION BEAMS"

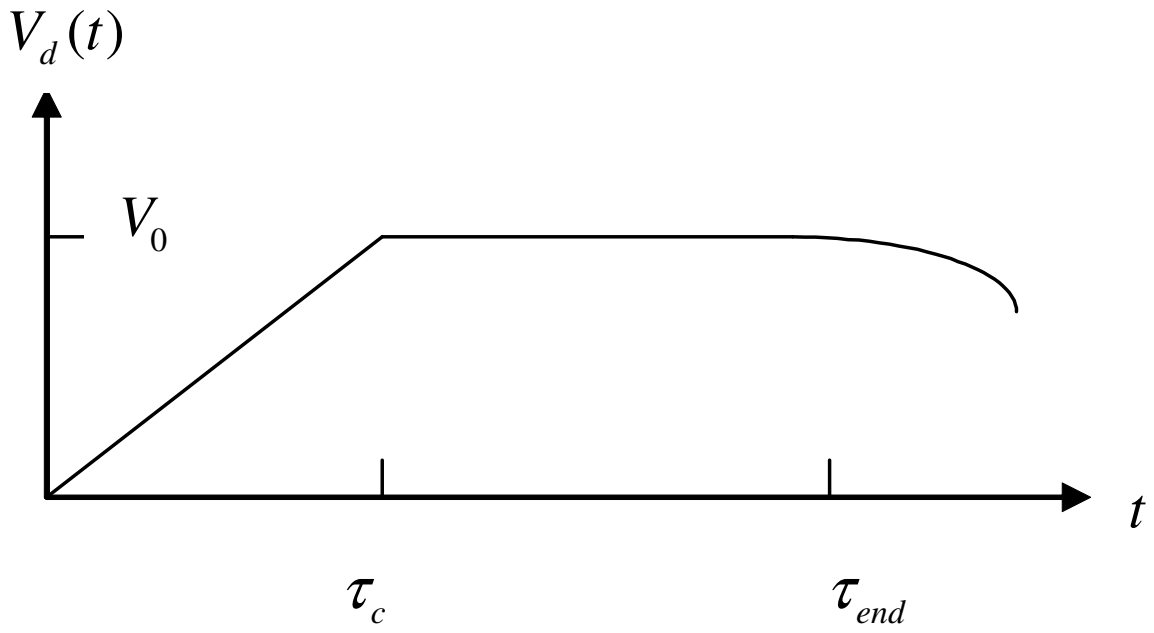
What PLIA parameters would be required to bunch the Li beam in the present NDCX-II injector design concept to ~ 60 ns at its output?

- Provides an alternate approach to the current baseline front end using 10 -12 ATA cells, with each one requiring a special pulser
- Assume present accel-decel injector design

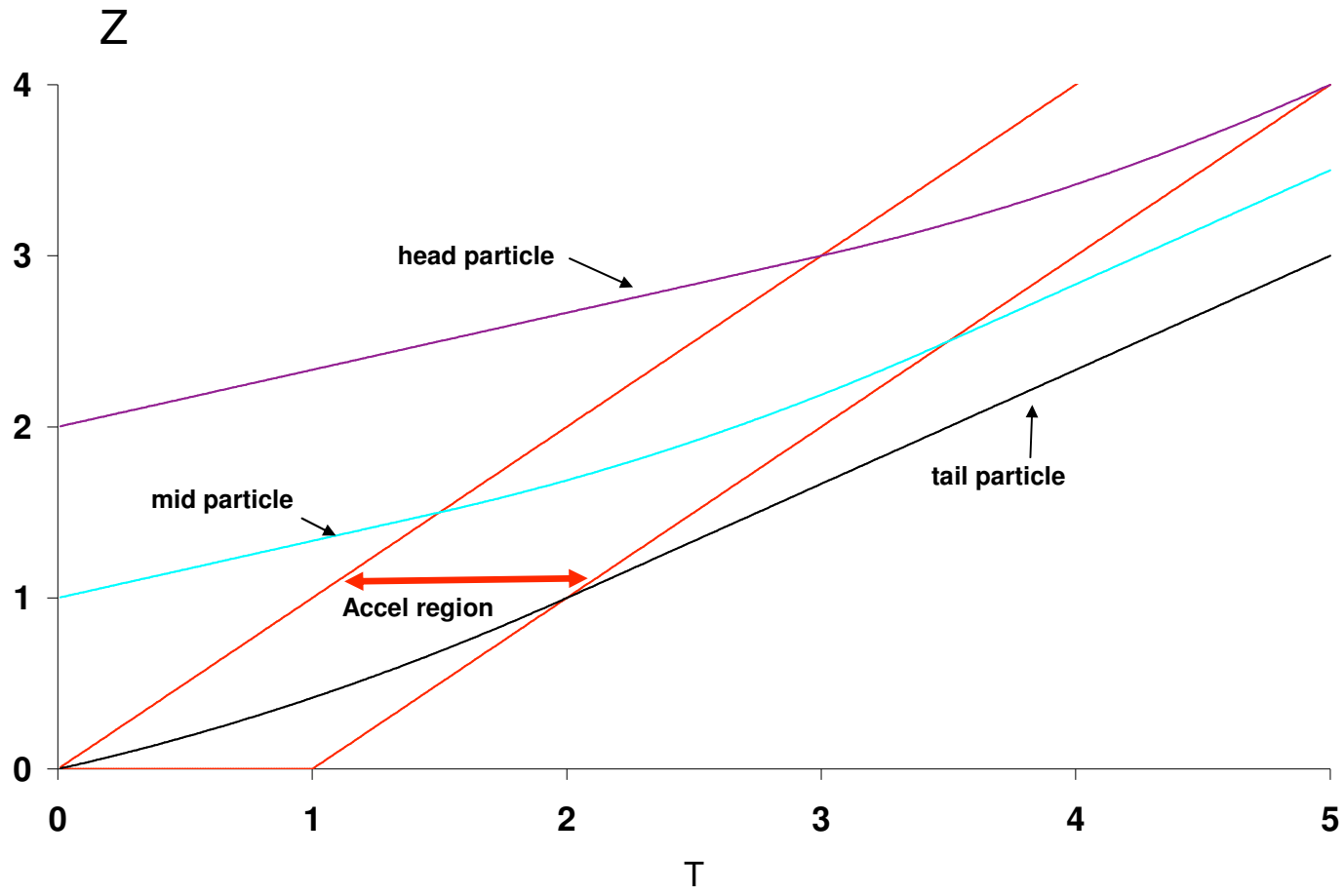
  (100 ma, 100 kV Li beam, 0.6 to 0.8 m long initially)
- NOTE – initial line charge density is ~ 1/3 (and Q ~ 1/6) compared to the previous NDCX-1c studies

A zero space charge analytic theory was used to estimate the PLIA parameters required to compress the bunch to ~ 60 ns

Idealized helix voltage waveform used for analytic estimates



The simplest snowplow mode was used to make the estimates: all ions exit with the same energy, including the Vo energy gain in the termination resistor region



Four examples with increasing Vo's that bunch a 60 cm long ion pulse from the injector to 60 ns at the PLIA output, with a wave ramp length of 30 cm

Vo	Ion energy out	Helix length	Bunching factor	Wave speed m/usec	Drive ramp duration	Drive flat-top duration
100 kV	400 kV	1.8 m	3.5	3.4	90 ns	60 ns
150 kV	500 kV	1.6 m	3.2	3.8	80 ns	60 ns
200 kV	600 kV	1.45 m	3.0	4.1	73 ns	60 ns
300 kV	780 kV	1.3 m	2.8	4.7	64 ns	60 ns

Four examples with increasing Vo's that bunch an 80 cm long ion pulse from the injector to 60 ns at the PLIA output, with a wave ramp length of 40 cm

Vo	Ion energy out	Helix length	Bunching factor	Wave speed m/usec	Drive ramp duration	Drive flat-top duration
100 kV	423 kV	2.5 m	4.5	3.3	120 ns	60 ns
150 kV	533 kV	2.2 m	4.1	3.7	108 ns	60 ns
200 kV	635 kV	2 m	3.9	4.05	98 ns	60 ns
300 kV	825 kV	1.8 m	3.5	4.6	86 ns	60 ns

PLIA parameters required to accelerate and bunch the injected Li beam are quite modest, based on this simple zero space charge model

- The existing oil helix with a 6 cm aperture radius and an 8.1 cm helix radius is a reasonable baseline for a PLIA design, changing the turns/m to optimize the wave speed.
- Acceleration gradients as low as 300 kV/m and helix voltages as low as 100 kV (peak-to-peak) are still interesting – these are within the limits already demonstrated
- The 200 kV, 60 cm ion bunch case is a good reference case for further study – and the circuit speed of ~ 4 m/usec can be obtained by putting insulator with rings in the original oil helix